

Air Quality Monitoring Near Livestock Feeding Operations in the Lethbridge Area September 1998 to July 1999

Summary

Alberta Environment conducted a mobile, ambient air quality survey in the Counties of Lethbridge and Warner for a period of ten days over four seasons between September 1998 and July 1999. The survey was in response to public complaints about odours in the area from livestock feeding operations. The survey found that concentrations of all compounds monitored during the survey were within Alberta's Ambient Air Quality Guidelines, with two exceptions. Both exceptions involved hydrogen sulphide. In each case the levels were recorded close to the source of odour.

The survey monitored for a number of air contaminants and determined maximum air quality levels for these substances. All monitoring was conducted downwind of livestock feeding operations. Observed concentrations were then compared to Alberta's ambient air quality guidelines.

Alberta Environment conducts mobile air quality surveys each year as part of its air quality monitoring program. The surveys are unannounced and use the department's Mobile Air Monitoring Laboratory. In 1999, Alberta Environment conducted 14 mobile air quality monitoring surveys in the province.

For the Lethbridge and Warner County's survey, the mobile lab monitored air quality near 14 livestock feeding operations and three control sites. The control sites were in Picture Butte, Stirling and at the Agriculture and Agri-Food Canada research station in Lethbridge. Alberta Environment staff chose sampling locations in the vicinity of livestock feeding operations based on the presence of odours in the area. The survey recorded approximately 50 hours of air quality monitoring information for the following substances: Hydrogen sulphide, ammonia, hydrocarbons, particulates (dust), ozone, sulphur dioxide, oxides of nitrogen and carbon monoxide.

At each site staff positioned the mobile lab downwind from the facility and monitored air quality for an hour. Hourly monitoring permits results to be compared with Alberta's Ambient Air Quality Guidelines, which are based on hourly averages. Staff repeated this monitoring process at each site. Staff conducted monitoring more often at sites where odour-causing compounds exceeded Alberta Environment guidelines than at sites where odour causing compounds were lower than the guidelines.

Findings

All substances detected were at levels within Alberta's Ambient Air Quality Guidelines and hourly ambient air quality guidelines, except hydrogen sulphide. Hydrogen sulphide was found at levels above provincial guidelines at two locations, and near the odour source. Guidelines for this substance are based on odour. Hydrogen sulphide is detectable by sensitive individuals as an odour at levels below the guidelines.

The maximum one-hour concentrations of hydrogen sulphide at two hog feeding operations were .054 parts per million (ppm) and .026 ppm. The provincial one-hour guideline for hydrogen sulphide is .010 ppm. Hydrogen sulphide levels monitored at all other sites were below provincial guidelines. Levels ranged from .001 to .008 ppm.

Ammonia concentrations varied between .001 and 1.364 ppm. These readings are below the provincial guideline of 2.0 ppm.

Conclusions

Hydrogen sulphide levels at two sites exceeded provincial guidelines with concentrations of .026 and .054 ppm respectively. These levels were detected within 30 metres of the source at each site and could generate enough odour to be considered strong by some people exposed to them. Hydrogen sulphide is detectable as odour by some people at levels as low as .004 ppm.

Alberta's Ambient Air Quality Guidelines

Alberta's Ambient Air Quality Guidelines¹ are established under Section 14 of the Environmental Protection and Enhancement Act (EPEA). EPEA provides for the development of guidelines and ambient environmental quality objectives for all or part of Alberta.

The Ambient Air Quality Guidelines are used in a number of ways:

- reporting on the state of the atmospheric environment in Alberta;
- reporting to Albertans on the quality of air through an air quality index;
- establishing approval conditions for regulated industrial facilities;
- evaluating proposals to construct facilities that will have air emissions;
- guiding special ambient air quality surveys; and
- assessing compliance near major industrial air emission sources.

¹ Alberta Ambient Air Quality Guidelines. Alberta Environment. February 2000.

Alberta's Ambient Air Quality Guidelines for one-hour concentrations of parameters monitored during this survey are indicated below.

Air Quality Parameter	One-hour Guideline (ppm*)	Basis for Guideline
hydrogen sulphide	0.01	odour perception
ammonia	2	odour perception
carbon monoxide	13	oxygen carrying capacity of blood
nitrogen dioxide	0.212	odour perception
ozone	0.082	reduction of lung function and effects on tomatoes
sulphur dioxide	0.172	taste, odour perception and effects on bluegrass

* parts per million by volume

Alberta Environment sets many of its ambient air quality guidelines on the basis of odour perception. Using odour as the basis of the guideline considers potential implications for human health because people are likely to smell an odour at concentrations well below levels that may affect human health. Appendices 1 and 2 show the relative concentrations of hydrogen sulphide and ammonia in relation to Alberta's ambient air quality guidelines; levels that may be detected as an odour; and levels that may affect human health. For both hydrogen sulphide

and ammonia, the concentrations detected during the survey were within odour thresholds and below levels that may affect human health according to the scientific literature.

Monitoring Method

The Alberta Environment Mobile Air Monitoring Laboratory (MAML) was used to monitor air quality for about 50 hours, over ten days, in the area of livestock feeding operations within the counties of Lethbridge and Warner. The focus of this monitoring was to determine the maximum concentration of pollutants downwind of feeding operations. Air quality was monitored on the following dates representing the fall, winter, spring, and summer seasons:

- fall (September 22 and 25, 1998);
- winter (February 22, 25, and 26, 1999);
- spring (May 10, 13, and 14, 1999); and
- summer (July 18 and 21, 1999).

The MAML monitored air quality at 17 sites in the Lethbridge area. The majority of these sites (14 sites) were located downwind of livestock feeding operations (eleven cattle operations and three hog operations). The other three sites were located in Picture Butte, Stirling and at the Agriculture and Agri-Food Canada Research

Station in Lethbridge. Monitoring was conducted for a minimum of one hour at each location to allow comparison with Alberta's air quality guidelines.

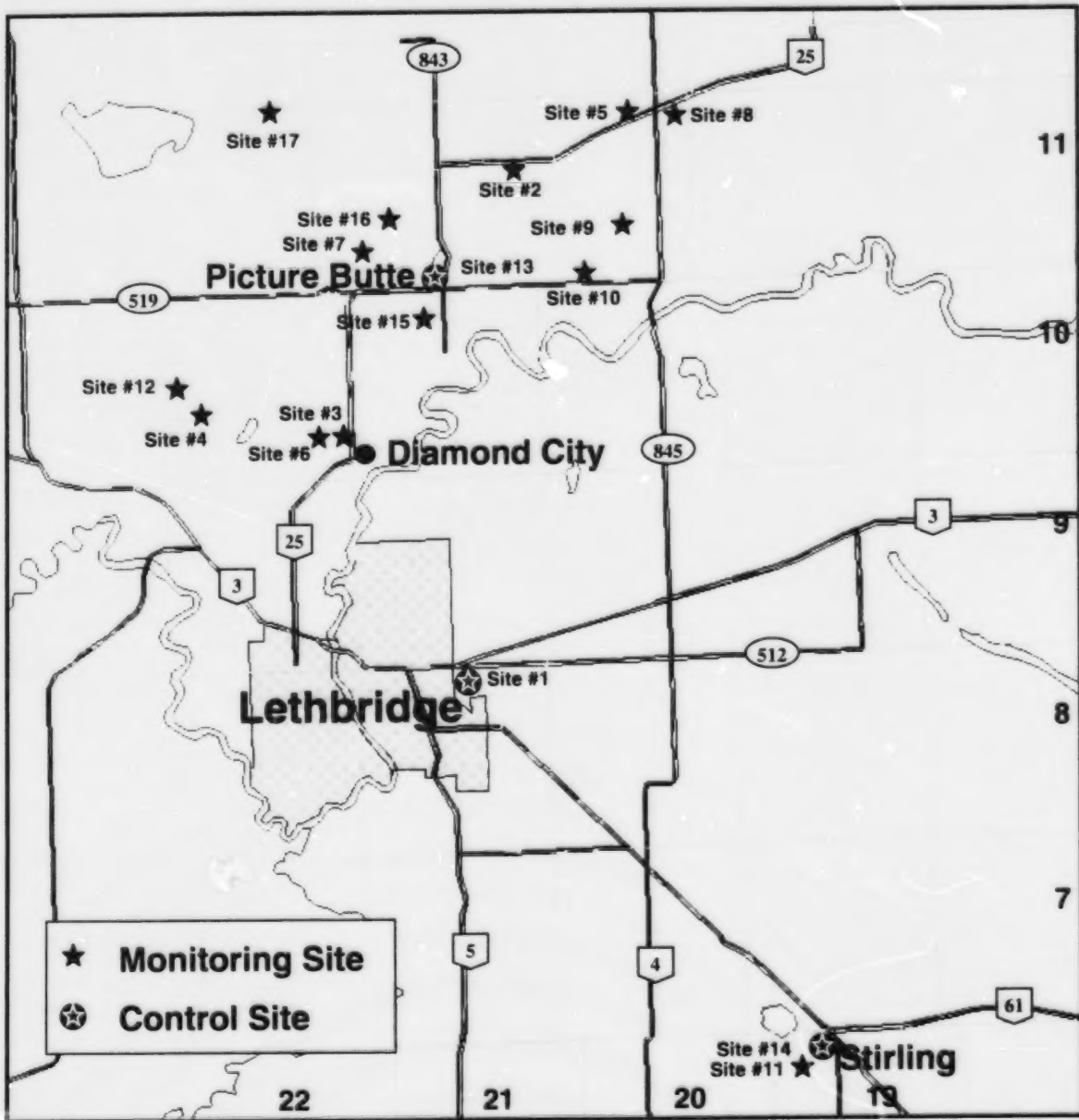
The MAML is a 27-foot (8.2 m) vehicle that has been specially designed and equipped to measure air quality. It houses a variety of instruments that continuously sample the air at specified time or distance intervals. The MAML is equipped with:

- a dual computer system custom-programmed to control the measurement of air samples from each analyzer;
- a GPS (Global Positioning System) that will identify the MAML's location as it moves around Alberta;
- an exhaust purifying system that minimizes emissions from the vehicle; and
- two on-board generators that are also equipped with exhaust scrubbers.

The parameters measured by the MAML during the 1998/99 livestock feeding operation survey are indicated below. Air quality parameter concentrations, weather conditions and the MAML operator's comments for each location monitored are indicated in Tables 1 to 5 at the end of this report.

Parameters Measured by the Mobile Air Monitoring Laboratory		
Parameter Measured	Minimum Detectable Limit	Operating Range
Sulphur dioxide (SO ₂)	0.6 ppb	1 ppm
Hydrogen sulphide (H ₂ S)	0.6 ppb	1 ppm
Total reduced sulphur (TRS)	0.6 ppb	1 ppm
Total hydrocarbons (THC)	0.005 ppm	20 ppm
Reactive hydrocarbons (RHC)	0.005 ppm	20 ppm
Methane (CH ₄)	0.005 ppm	10 ppm
Polycyclic aromatic hydrocarbons (PAHs)	3 ng/m ³	1000 ng/m ³
Ozone (O ₃)	0.001 ppm	0.5 ppm
Nitrogen dioxide (NO ₂)	1.0 ppb	1 ppm
Nitric oxide (NO)	1.0 ppb	1 ppm
Total oxides of nitrogen (NO _x)	1.0 ppb	1 ppm
Total suspended particulates (TSP)	1 µg/m ³	1.0 g/m ³
Inhalable particulates (PM ₁₀)	1 µg/m ³	1.0 g/m ³
Respirable particulates (PM _{2.5})	1 µg/m ³	1.0 g/m ³
Carbon monoxide (CO)	0.1 ppm	50 ppm
Ammonia (NH ₃)	1.0 ppb	2 ppm
Wind direction (WDR)	0 degrees	360 degrees
Wind speed (WSP)	0 kph	200 kph
Temperature (Temp)	-40 °C	50 °C
Relative humidity (RH)	0 %	100 %

ppb = parts per billion ppm = parts per million ng/m³ = nanograms per cubic metre µg/m³ = micrograms per cubic metre
g/m³ = grams per cubic metre kph = kilometres per hour °C = degrees Celsius % = per cent



Location of Monitoring Sites in the Livestock Feeding Operations Survey

Monitoring Locations, # of Complete Hours Monitored and Dates Monitored			
Site	Site Location	# of Complete Hours Monitored	Dates Monitored
Site# 1 *	Agriculture and Agri-Food Canada (5403-1st. Ave, S Lethbridge)	2	May 14, 1999
Site# 2	Hwy 25 between Rge Rd 20-5 & Rge Rd 21-0 (Cattle Feeding Operation)	1	July 21, 1999
Site# 3	Hwy 25 & Twp Rd 10-1A (Cattle Feeding Operation)	5	September 25, 1998; February 22 & 25, 1999; May 10 & July 21, 1999
Site# 4	Rge Rd 22-5 & 1/4 mi S of Twp Rd 10-3 (Cattle Feeding Operation)	1	February 26, 1999
Site# 5	Rge Rd 20-2 & Hwy 25 (Cattle Feeding Operation)	1	May 13, 1999
Site# 6	Rge Rd 22-1 & Twp Rd 10-1A (Cattle Feeding Operation)	1	February 25, 1999
Site# 7	1 mi down Rge Rd 21-4 (off Hwy 25) (Cattle Feeding Operation)	1	May 13, 1999
Site# 8	30m S of Hwy 25 E side of Hwy 845 (Cattle Feeding Operation)	1	July 18, 1999
Site# 9	Rge Rd 20-3 & 1 1/4 mi N of Hwy 519 (Cattle Feeding Operation)	1	May 13, 1999
Site#10	1/2 mi. W of Rge Rd 20-3 on Hwy. 519 (Cattle Feeding Operation)	1	May 10, 1999
Site#11	300m S of 6th Ave & 8th St, Stirling (Cattle Feeding Operation)	2	Feb 25 & May 13, 1999
Site#12	Rge Rd 23-0 & 1/2 mi S of Twp Rd 10-4 (Hog Feeding Operation)	2	September 22 1998
Site#13 *	Picture Butte (Lions Park)	12	September 22 & 25, 1998; February 22, 25 & 26, 1999; May 10, 13 & 14, 1999; July 18 & 21, 1999
Site#14 *	Stirling (6th Ave & 4th St)	3	September 25, 1998; February 25, 1999; May 13, 1999
Site#15	Rge Rd 21-4 & 2/3 mi S of Hwy 25 (Hog Feeding Operation)	1	July 18, 1999
Site#16	Rge Rd 21-3 & Twp Rd 11-2 (Hog Feeding Operation)	8	September 22, 1998; Feb 22, 25 & 26, 1999; May 14, 1999; July 18 & 21, 1999
Site#17	Twp Rd 12-0 to 11-5 on Rge Rd 22-1 (Cattle Feeding Operation)	4	July 21, 1999

* Control site.



Hydrogen Sulphide and Total Reduced Sulphur (H_2S and TRS)

max. one-hour concentration recorded during survey	one-hour guideline
H_2S = 0.054 ppm	0.010 ppm (based on odour perception)
TRS = 0.054 ppm	no guideline

Hydrogen sulphide (H_2S) is a colourless gas with a rotten egg odour. Total reduced sulphur (TRS) includes hydrogen sulphide, mercaptans, dimethyl sulphide, dimethyl disulphide and other sulphur compounds. Sulphur dioxide is not included in the determination of TRS. Industrial sources of H_2S and TRS include fugitive emissions (leakages) from petroleum refineries, tank farms for unrefined petroleum products, natural gas plants, petrochemical plants, oil sands plants, sewage treatment facilities, pulp and paper plants that use the Kraft pulping process, and animal feeding operations. Natural sources of H_2S include sulphur hot springs, sloughs, swamps and lakes.

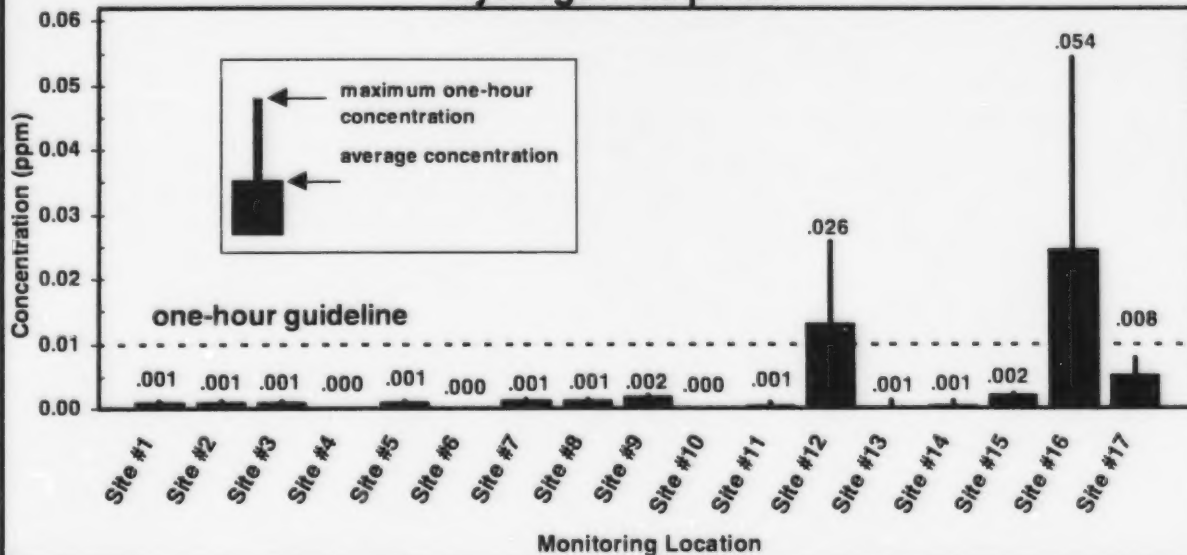
Concentrations of H_2S were higher than Alberta's one-hour guideline of 0.010 ppm at two sites monitored during the livestock feeding operation survey. A maximum one-hour concentration of 0.054 ppm was recorded on May 14 from 10:20 to 11:23 a.m. (M.S.T.) at Site #16. The one-hour guideline was also exceeded five other times at

Site #16 during the survey. All of these exceedances were measured about 30 metres from the site. A total of eight hours of data were collected at Site #16. H_2S levels at Site #12 exceeded the one-hour guideline from 6:24 to 7:24 p.m. (M.S.T.) on September 22. The one-hour H_2S concentration recorded at this time was 0.026 ppm. Monitoring was conducted about 25 metres from the site when this exceedance was recorded. However, at a distance of one-quarter mile from Site #12, H_2S levels were barely detectable (0.001 ppm). Two hours of data were collected at Site #12. H_2S at Sites #16 and #12 likely was due to nearby hog feeding operations. For more information on H_2S from hog operations, refer to Appendix 3.

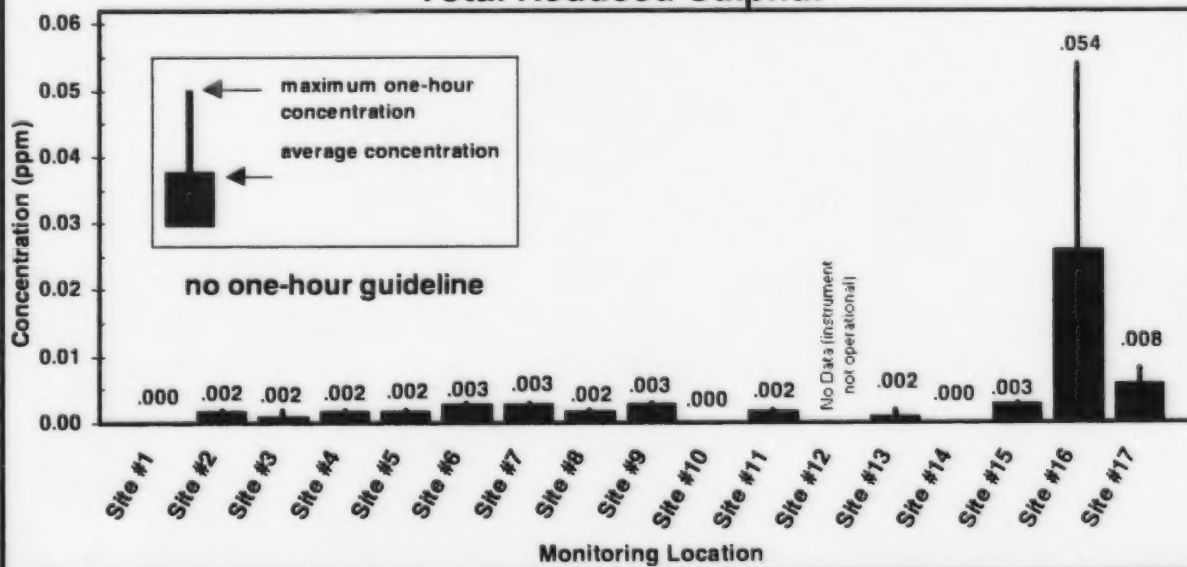
Alberta's one-hour guideline for H_2S of 0.010 ppm is based on odour perception. Therefore, H_2S levels exceeding the guideline would have been detected as an odour. Sensitive individuals may detect H_2S as an odour at levels below the one-hour guideline.

H_2S levels were well below the one-hour guideline at the control sites located in Picture Butte (Site #13), Lethbridge (Site #1) and Stirling (Site #14). The maximum one-hour H_2S concentration recorded at these locations was 0.001 ppm compared to the one-hour guideline of 0.010 ppm.

Hydrogen Sulphide



Total Reduced Sulphur



Ammonia (NH₃)

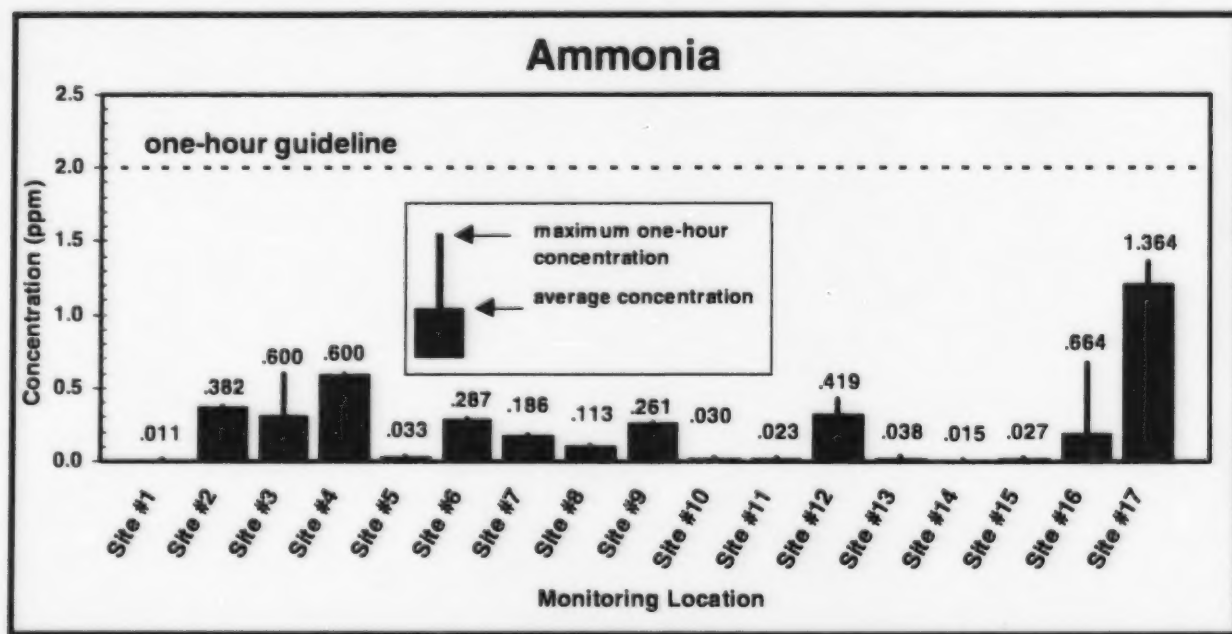
max. one-hour concentration recorded during survey	one-hour guideline
1.364 ppm	2.0 ppm (based on odour perception)

Ammonia is a colourless gas with the well-known pungent odour found in household cleaners. NH₃ is produced both by natural and man-made sources. Some natural sources of NH₃ include the decay of plant material and animal waste. In Alberta, the fertilizer industry is the main industrial source of NH₃. The industry produces synthetic NH₃ for either direct application to soil as a fertilizer, or as a raw material for use in the production of other high nitrogen fertilizer products. Commercial feeding operations are also a source of NH₃, specifically from animal waste.

Ammonia concentrations were below Alberta's ambient air quality guidelines near all feeding operations monitored in the Lethbridge area. The maximum one-hour average concentration recorded during the entire survey was 1.364 ppm. The concentration recorded during this time period was 68% of the one-hour guideline for NH₃ of 2.0 ppm.

The next highest one-hour NH₃ concentrations measured were from 0.6 to 0.7 ppm. These NH₃ levels were below the one-hour guideline of 2.0 ppm.

Maximum one-hour NH₃ levels at Picture Butte (Site #13), Stirling (Site #14) and Lethbridge (Site #1) control sites were 0.038, 0.015 and 0.011 ppm, respectively. These values are well below the one-hour guideline for NH₃.



Hydrocarbons (THC, RHC and CH₄)

max. one-hour concentration recorded during survey	one-hour guideline
THC = 9.5 ppm	no guideline
RHC = 1.6 ppm	no guideline
CH ₄ = >7.1 ppm	no guideline

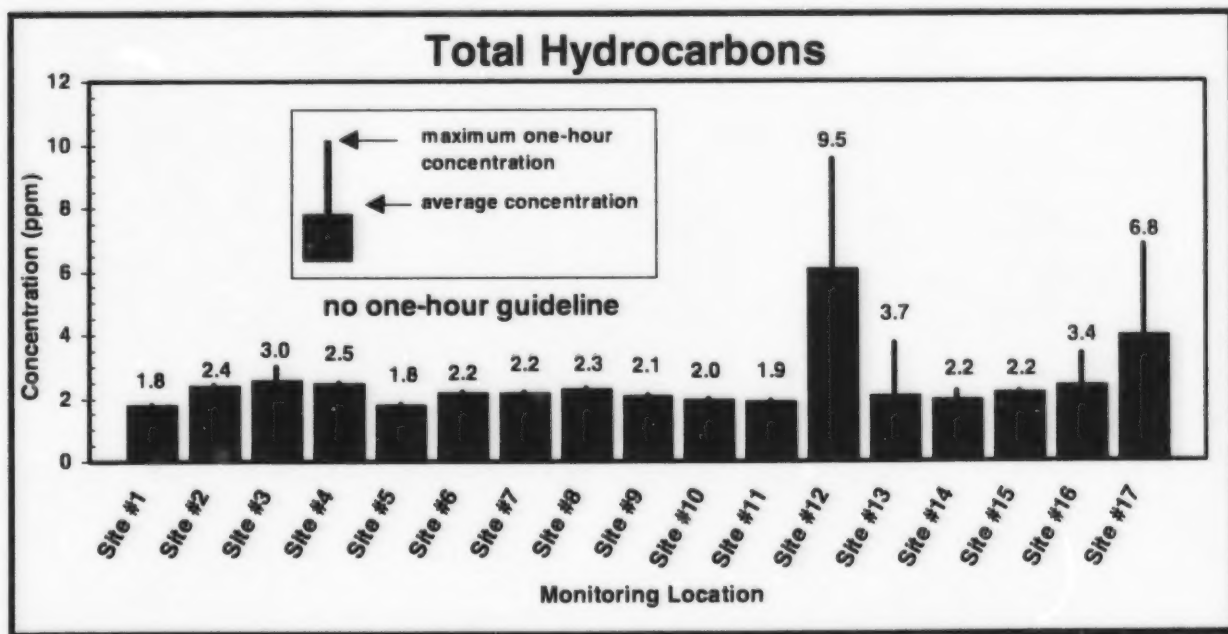
The term "total hydrocarbons" (THC) refers to a broad family of chemicals that contain carbon and hydrogen atoms. Methane (CH₄), a non-reactive hydrocarbon, is the most common hydrocarbon in the earth's atmosphere. CH₄ is colourless, odourless and non-toxic. Specific reactive hydrocarbons (RHC) are important because: (1) they can react with oxides of nitrogen in the presence of sunlight to form ozone; and (2) they can be toxic (at high concentrations) to humans, animals or vegetation. Sources of hydrocarbons include vegetation, vehicle emissions, gasoline marketing and storage tanks, petroleum and chemical industries, dry cleaning, fireplaces, natural gas combustion and aircraft traffic. Animal flatulence and animal waste can also be a source of methane and some reactive hydrocarbons such as volatile organic and fatty acids. These volatile organic and fatty acids can contribute to the odour from livestock feeding operations.

Hydrocarbon levels in the background atmosphere range from about 1.5 to 2.0 ppm. This is primarily because of natural sources of CH₄.

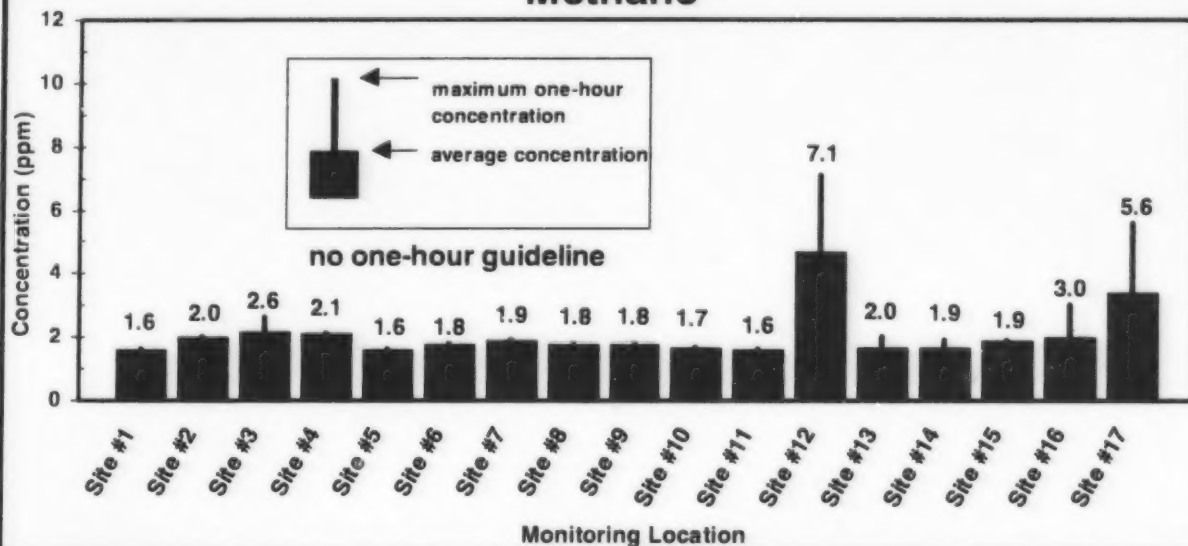
The maximum one-hour THC value measured during the survey was 9.5 ppm. The highest CH₄ concentration was recorded at the same site with a one-hour maximum value of 7.1 ppm. The maximum one-hour RHC concentration was 1.6 ppm. Based on overall average concentrations at each monitoring site, CH₄ made up from 75 to 90% of the THC concentrations.

Hydrocarbon levels at control sites located in Lethbridge (Site #1) and Stirling (Site #14) were close to normal background levels with maximum one-hour THC concentrations of 1.8 and 2.2 ppm measured at these two sites, respectively. The maximum one-hour THC concentration measured in Picture Butte (Site #13) was 3.8 ppm. Slightly higher hydrocarbon concentrations in Picture Butte were likely due to local vehicle traffic.

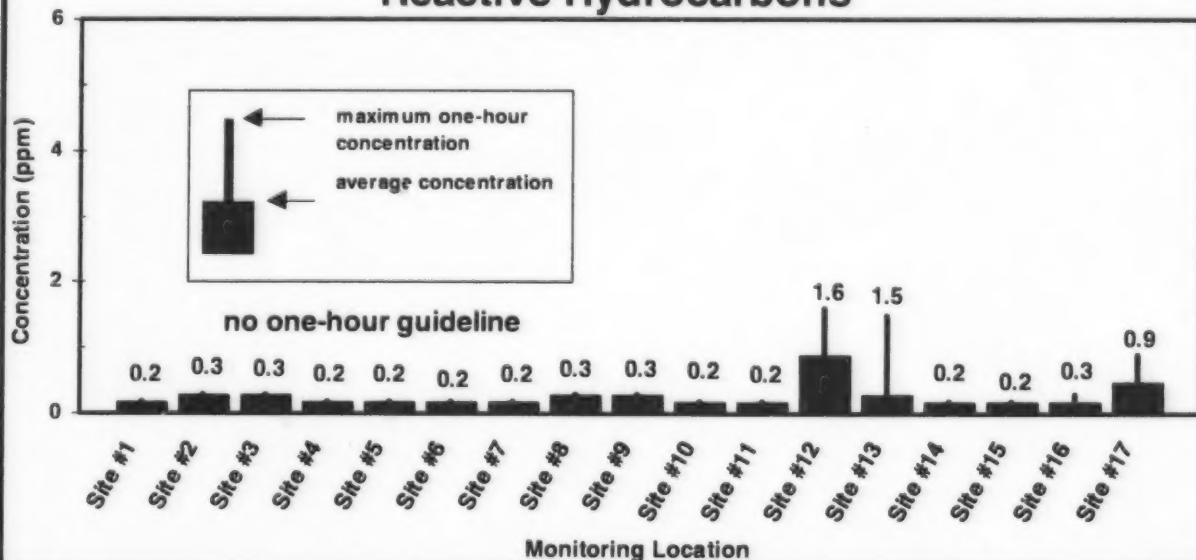
Because of the different environmental effects of individual hydrocarbons, Alberta does not have ambient air quality guidelines for THC or RHC. There are no guidelines for CH₄ because it is a non-toxic, odourless gas.



Methane



Reactive Hydrocarbons



Particulates (TSP, PM₁₀ and PM_{2.5})

max. one-hour concentration recorded during survey	one-hour guideline
TSP = 490 µg/m ³	no guideline
PM ₁₀ = 298 µg/m ³	no guideline
PM _{2.5} = 32 µg/m ³	no guideline

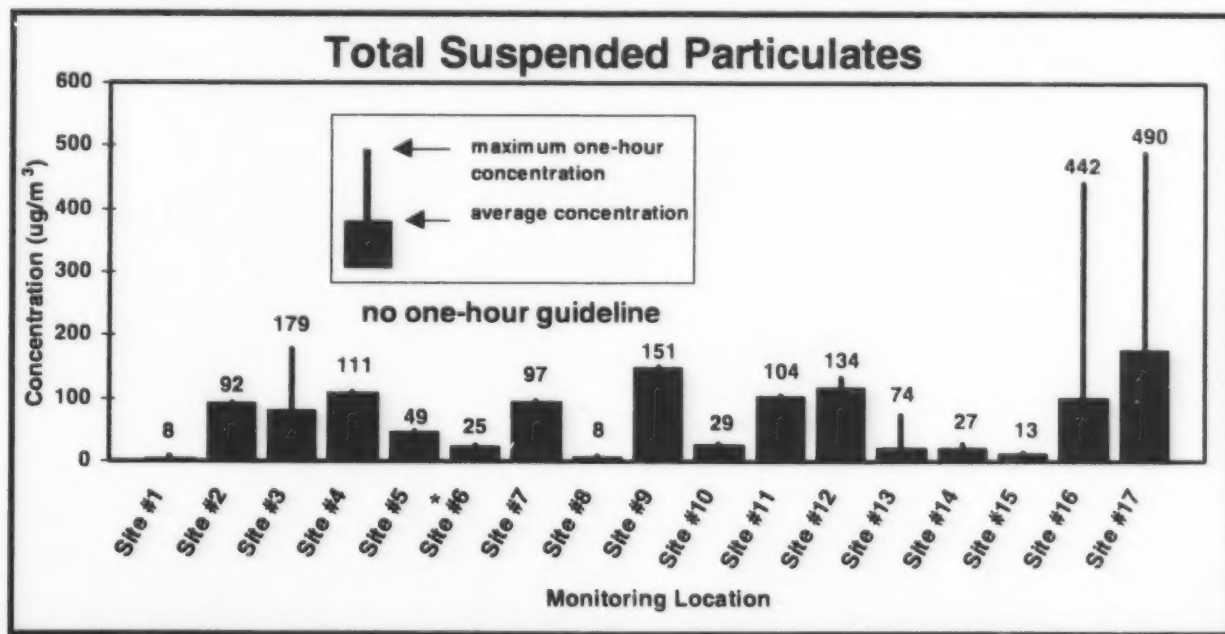
Air pollutants are not necessarily in a gaseous form. Tiny particles of solid material or liquid droplets, defined collectively as particulates, are also present in the atmosphere. Total suspended particulates (TSP) refer to all particles up to 500 microns in diameter (a human hair is about 100 microns in diameter) and are important primarily from a nuisance perspective. Particles less than 10 microns in diameter (PM₁₀) can be inhaled into the nose and throat while smaller particles, less than 2.5 microns in diameter (PM_{2.5}), can penetrate into the lungs. Sources of particulates include soil dust, road dust, agricultural dust (e.g., harvest), smoke from forest fires and recreational wood burning, vehicle exhaust emissions, brake and tire wear, industrial emissions and livestock feeding operations. Smaller particles (PM_{2.5}) originate in the atmosphere because of condensation and combustion from sources such as vehicle exhaust emissions, industrial emissions and wood burning.

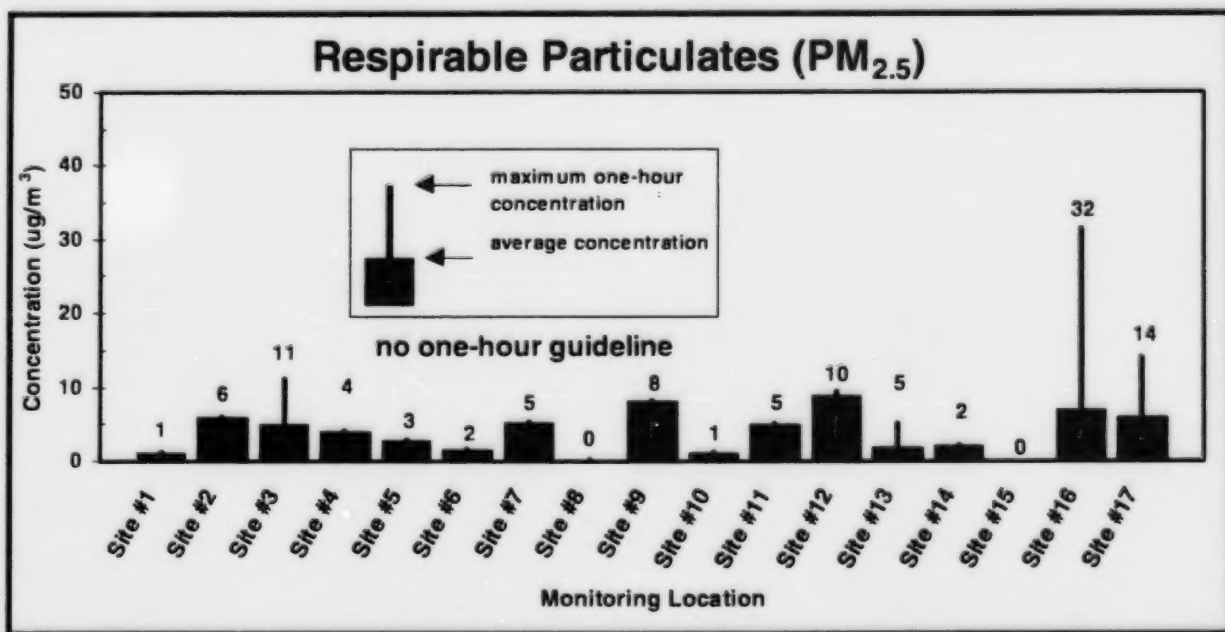
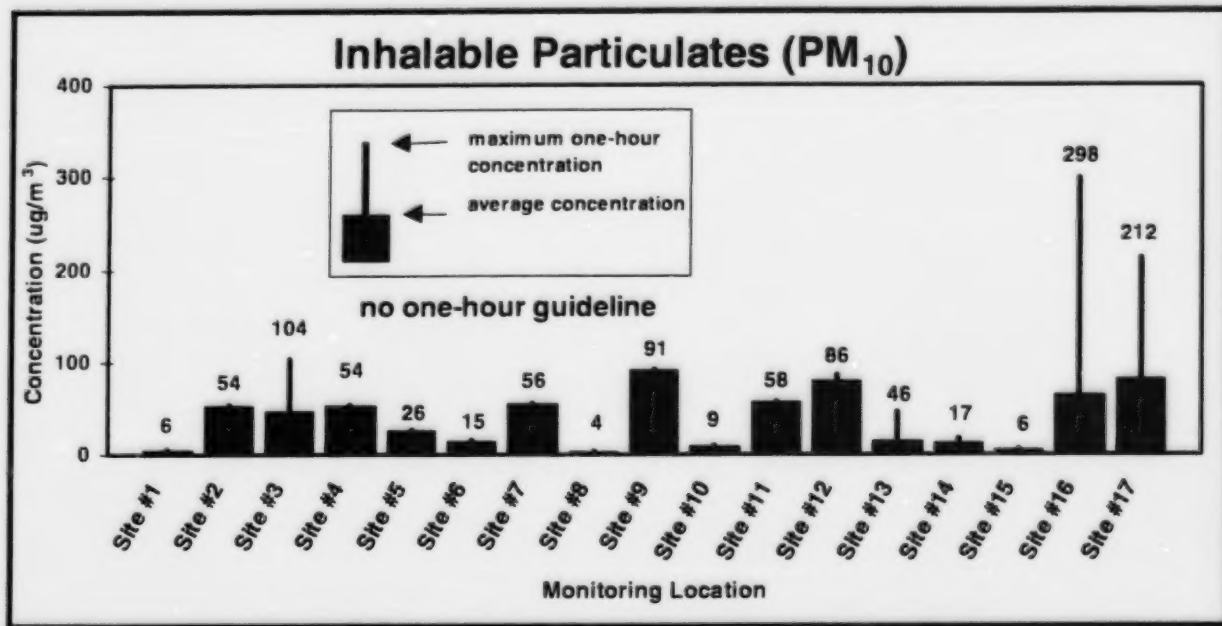
Maximum one-hour TSP, PM₁₀ and PM_{2.5} concentrations observed during this survey were 490, 212 and 14 µg/m³, respectively. Alberta does

not have one-hour guidelines for particulates. However, the 24-hour guideline for TSP in Alberta is 100 µg/m³. There is also a proposed 24-hour Canada-wide Standard (CWS) for PM_{2.5} of 30 µg/m³. Data collected in this survey is based on one-hour concentrations and cannot be compared directly to the 24-hour guideline for TSP or the proposed 24-hour CWS for PM_{2.5}.

Particulate matter monitored in the survey area was likely caused by the combination of numerous potential sources in the area. Some of these sources include road dust, wind blown soil, and dust generated during harvest operations and livestock feeding operations. The individual particulate sources could not be distinguished during this survey. Since PM_{2.5} are primarily the result of combustion and condensation, feeding operations are not expected to be a major source of PM_{2.5}.

The maximum one-hour TSP levels measured at the control sites in Picture Butte (Site #13), Lethbridge (Site #1) and Stirling (Site #14) were 74, 8 and 27 µg/m³, respectively. Maximum one-hour PM₁₀ concentrations at these three sites were 46, 6 and 17 µg/m³, respectively. PM_{2.5} concentrations were 5 µg/m³ or less at sites located in Picture Butte, Lethbridge and Stirling.





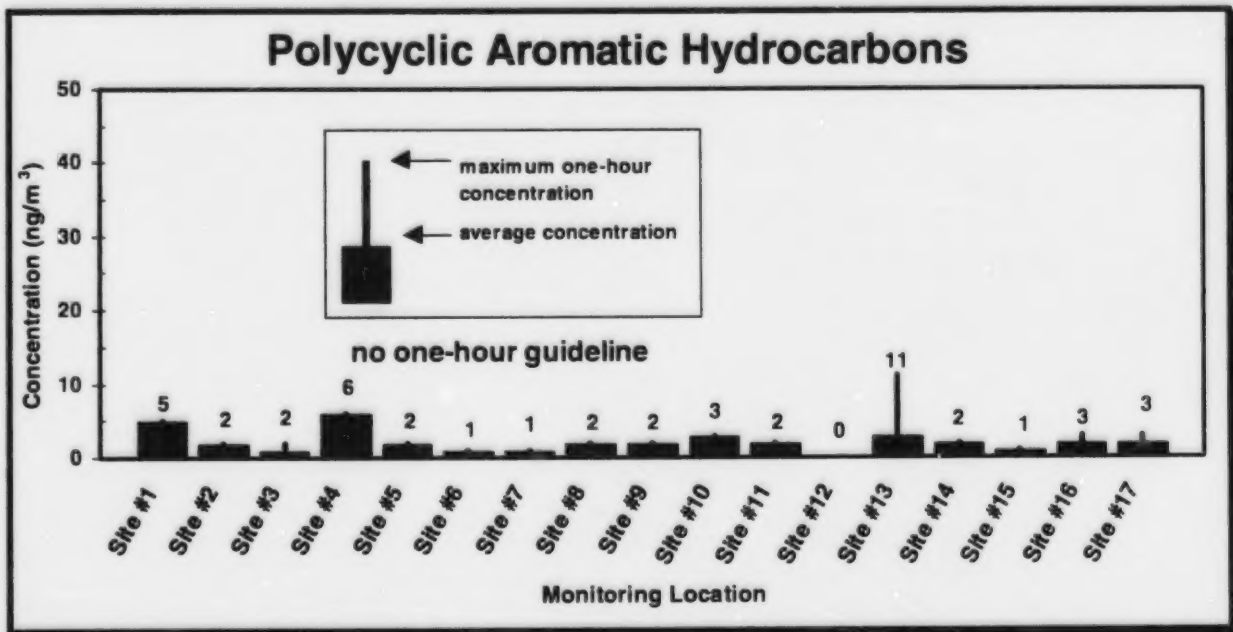
Polycyclic Aromatic Hydrocarbons (PAHs)

max. one-hour concentration recorded during survey	one-hour guideline
11 ng/m ³	no guideline

Polycyclic aromatic hydrocarbons (PAHs) are a class of chemicals that are contained in soot and smoke. There are more than 100 different PAHs with varying levels of toxicity. They are formed during the incomplete combustion of gasoline, diesel, oil, coal, wood, garbage or other organic substances. Tobacco smoke and charbroiled meats are common sources of PAHs. Other outdoor PAH sources include vehicle exhaust emissions, wood smoke from fireplaces, smoke from forest fires and industrial facilities. PAHs occur in the atmosphere in

the vapour phase or attached to dust particles. The PAH monitoring instrument aboard the MAML will analyze only particulate bound PAHs.

PAH levels were 11 ng/m³ (nanograms per cubic metre) or less during the survey. The highest one-hour concentration was recorded in Picture Butte. PAHs in Picture Butte are likely caused by vehicle emissions. Alberta does not have ambient air quality guidelines for total PAHs. This is because individual PAHs have different potential effects and therefore a single guideline for all PAHs would not be practical. PAHs are produced by incomplete combustion and therefore are not generated by livestock feeding operations.



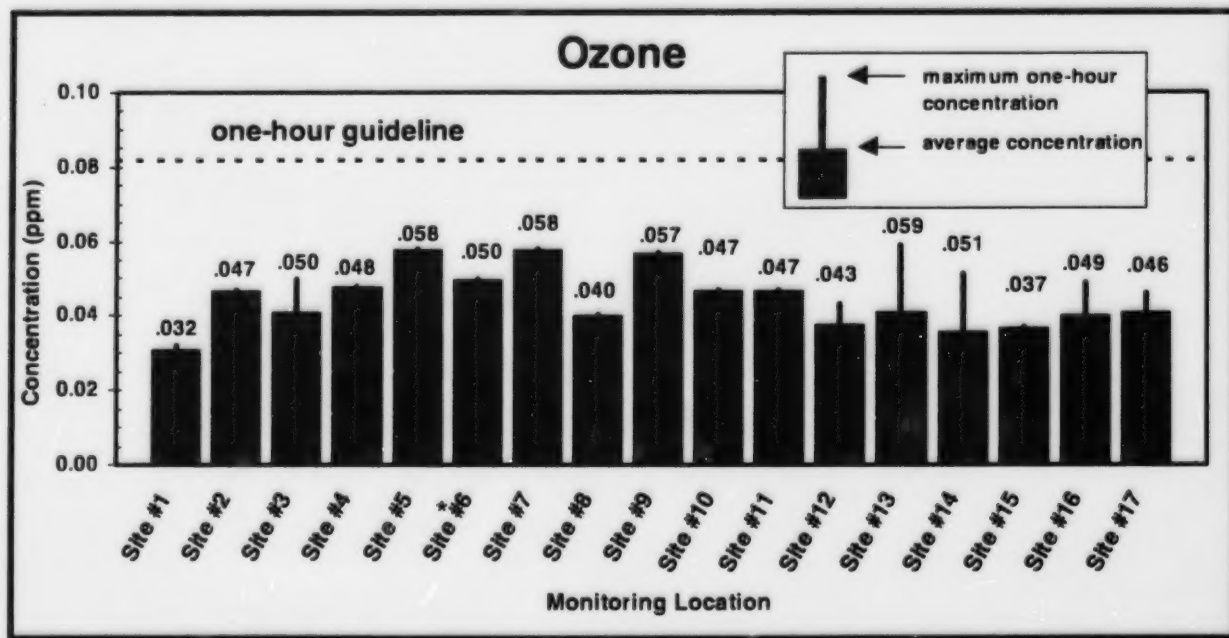
Ozone (O₃)

max. one-hour concentration recorded during survey	one-hour guideline
0.059 ppm	0.082 ppm (based on reduction of lung function and effects on tomatoes)

Ozone in the lower atmosphere is produced by: (1) the reaction of oxides of nitrogen and volatile organic compounds in the presence of sunlight, and (2) transport of O₃ from the upper atmosphere to ground level. Transport from the upper atmosphere is likely the dominant ozone producing process in the fall, winter and early spring seasons. O₃ concentrations are generally lower in urban centres due to the destruction of O₃ by nitric oxide.

O₃ concentrations in the feeding operation survey area followed typical daily and seasonal variations expected for rural locations in Alberta. Concentrations were generally highest in the late afternoon of the spring and summer seasons.

O₃ concentrations in the survey area were similar to those recorded at rural locations in Alberta. The average O₃ value in the survey was 0.045 ppm, which is similar to values recorded at the rural monitoring stations located near Drayton Valley (Violet Grove) and Hinton (High Tower Ridge). Average O₃ values at these two stations were 0.044 and 0.045 ppm, respectively, for the same monitoring period. O₃ concentrations are generally higher in rural locations than urban areas because of fewer vehicles. As mentioned earlier, nitric oxide emitted by vehicles will destroy naturally produced O₃. Livestock feeding operations do not generate O₃.

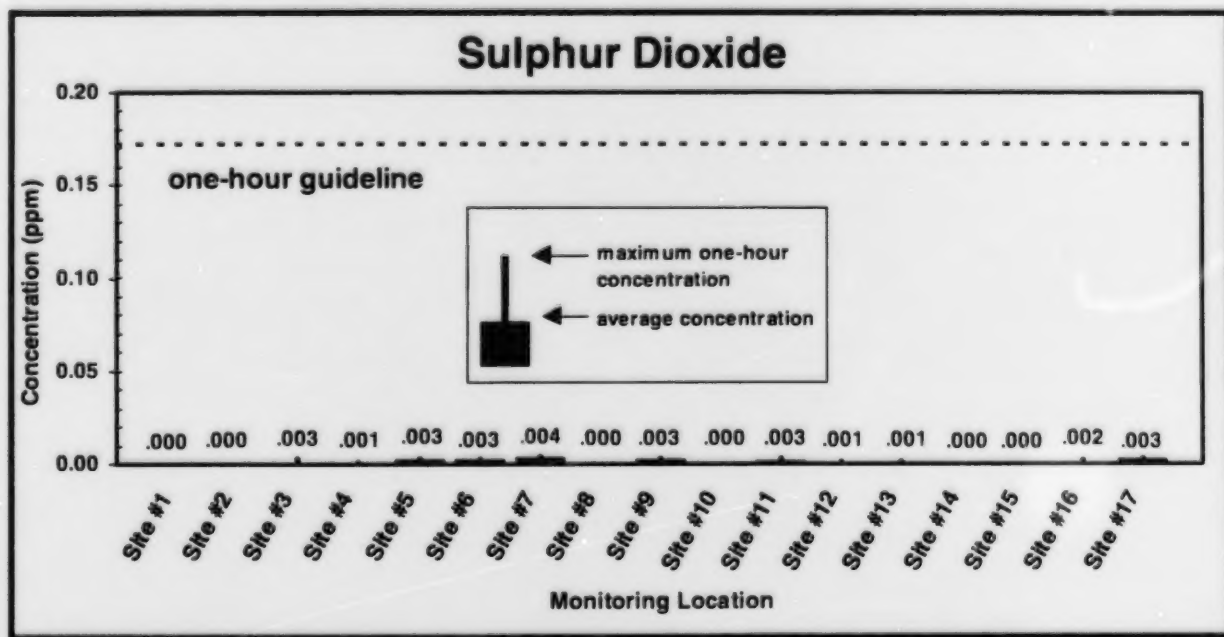


Sulphur Dioxide (SO₂)

max. one-hour concentration recorded during survey	one-hour guideline
0.004 ppm	0.172 ppm (based on taste, odour perception and effects on bluegrass)

Sulphur dioxide (SO₂) is a colourless gas with a pungent odour. In Alberta, the major sources of SO₂ are natural gas processing plants, oil sands facilities, and power plants. Other sources include gas plant flares, oil refineries, pulp and paper mills and fertilizer plants.

SO₂ levels were well below Alberta's one-hour guideline in this survey. The maximum one-hour concentration recorded during the survey was 0.004 ppm. This value is 2% of the one-hour guideline for SO₂. SO₂ concentrations were very low for the remainder of the monitoring period, with one-hour concentrations of 0.003 ppm or less. The maximum one-hour SO₂ concentrations measured at Picture Butte, Lethbridge and Stirling monitoring control sites were less than 0.001 ppm. SO₂ is not generated by livestock feeding operations.



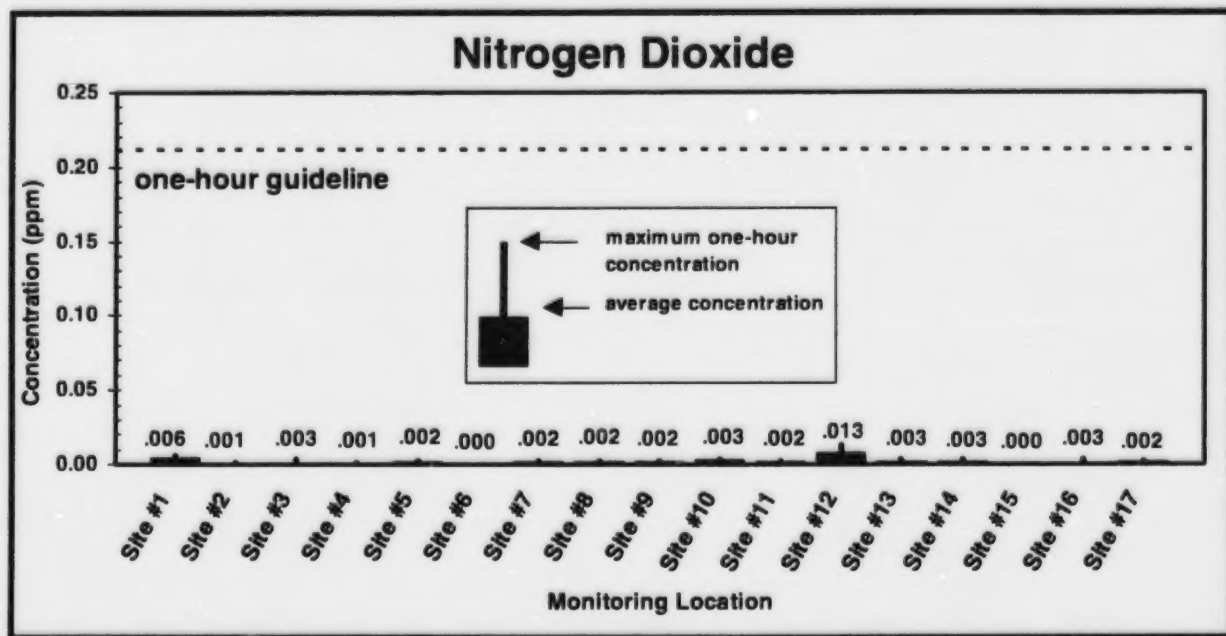
Oxides of Nitrogen (NO_2 , NO , NO_x)

max. one-hour concentration recorded during survey	one-hour guideline
$\text{NO}_2 = 0.013 \text{ ppm}$	0.212 ppm (based on odour perception)
$\text{NO} = 0.007 \text{ ppm}$	no guideline
$\text{NO}_x = 0.018 \text{ ppm}$	no guideline

Oxides of nitrogen (NO_x) are the total of nitrogen dioxide (NO_2) and nitric oxide (NO). During high temperature combustion - as in the burning of natural gas, coal, oil and gasoline - atmospheric nitrogen may combine with molecular oxygen to form NO . NO is colourless and odourless. Most NO in the ambient air is oxidized to form NO_2 . NO_2 is a

reddish-brown gas with a pungent odour. The major source of oxides of nitrogen in urban areas is vehicle exhaust emissions. Processes associated with the oil and gas industry also emit oxides of nitrogen into the atmosphere.

NO_2 concentrations were well below Alberta's one-hour guideline in the survey. The maximum one-hour average NO_2 concentration recorded during the survey was 0.013 ppm. This maximum value is 6% of the one-hour guideline for NO_2 of 0.212 ppm. Oxides of nitrogen (NO_2 , NO and NO_x) measured in the survey area were likely due to vehicle exhaust emissions. Livestock feeding operations do not generate NO or NO_2 .



Carbon Monoxide (CO)

max. one-hour concentration recorded during survey	one-hour guideline
1.2 ppm	13 ppm (based on the oxygen-carrying capacity of blood)

Carbon monoxide (CO) is a colourless, odourless gas emitted into the atmosphere primarily by motor vehicles. Minor sources include fireplaces, industry, aircraft and natural gas combustion. The major

source of carbon monoxide is vehicle exhaust emissions.

CO values were well below Alberta's ambient air quality guidelines in the livestock feeding operation survey. A maximum one-hour concentration of 1.2 ppm was recorded during the survey. This maximum value is 9% of the one-hour guideline for CO of 13 ppm. Vehicle exhaust emissions is the major source of CO. Livestock feeding operations do not emit CO.

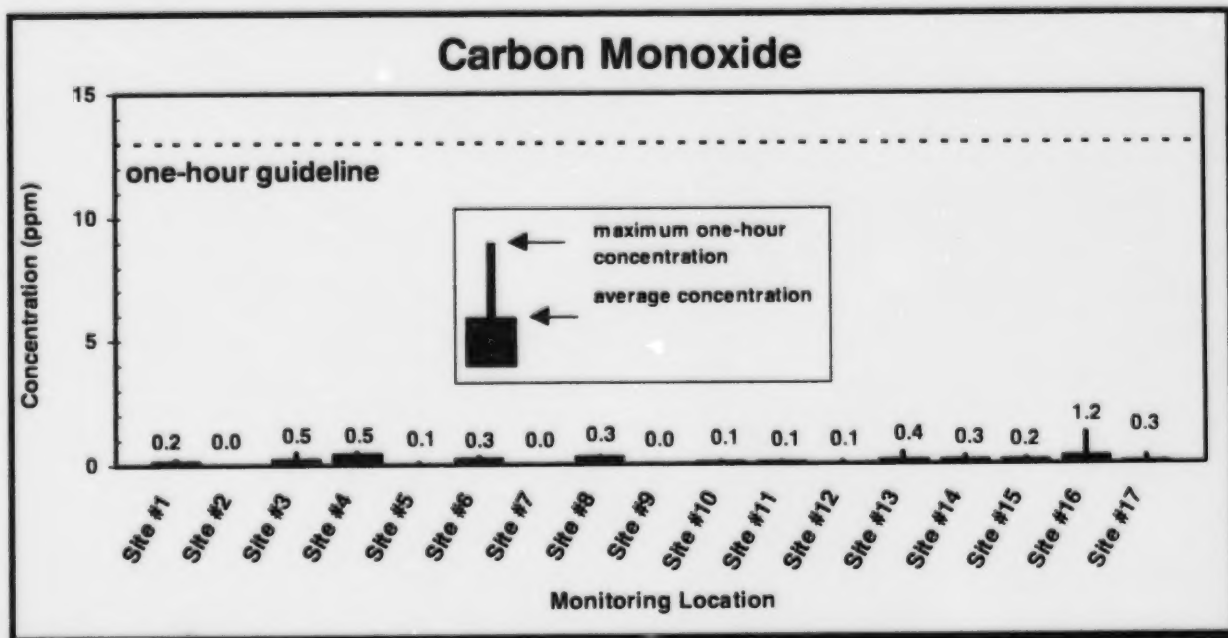


Table 1 shows **overall average** air quality parameter concentrations at individual monitoring locations.

Table 1 : Overall Average Air Quality Parameter Concentrations at each Site **																
Monitoring Location	CO (ppm)	O ₃ (ppm)	THC (ppm)	CH ₄ (ppm)	RHC (ppm)	SO ₂ (ppm)	NO (ppm)	NO ₂ (ppm)	NO _x (ppm)	NH ₃ (ppm)	TRS (ppm)	H ₂ S (ppm)	TSP (µg/m ³)	PM ₁₀ (µg/m ³)	PM _{2.5} (µg/m ³)	PAH (ng/m ³)
Site #1	0.2	0.031	1.8	1.6	0.2	0.000	0.003	0.005	0.008	0.009	0.000	0.001	7	5	1	5
Site #2	0.0	0.047	2.4	2.0	0.3	0.000	0.000	0.001	0.000	0.382	0.002	0.001	92	54	6	2
Site #3	0.3	0.041	2.6	2.2	0.3	0.001	0.002	0.001	0.003	0.318	0.001	0.001	81	47	5	1
Site #4	0.5	0.048	2.5	2.1	0.2	0.001	0.005	0.001	0.006	0.600	0.002	0.000	111	54	4	6
Site #5	0.1	0.058	1.8	1.6	0.2	0.003	0.001	0.002	0.003	0.033	0.002	0.001	49	26	3	2
Site #6	0.3	0.050	2.2	1.8	0.2	0.003	0.001	0.000	0.001	0.287	0.003	0.000	25	15	2	1
Site #7	0.0	0.058	2.2	1.9	0.2	0.004	0.000	0.002	0.002	0.186	0.003	0.001	97	56	5	1
Site #8	0.3	0.040	2.3	1.8	0.3	0.000	0.003	0.002	0.002	0.113	0.002	0.001	8	4	0	2
Site #9	0.0	0.057	2.1	1.8	0.3	0.003	0.001	0.002	0.003	0.261	0.003	0.002	151	91	8	2
Site #10	0.1	0.047	2.0	1.7	0.2	0.000	0.003	0.003	0.006	0.030	0.000	0.000	29	9	1	3
Site #11	0.1	0.047	1.9	1.6	0.2	0.002	0.005	0.002	0.007	0.023	0.002	0.000	104	58	5	2
Site #12	0.0	0.038	6.1	>4.7	0.9	0.001	0.003	0.008	0.010	0.332	no data	0.013	120	80	9	no data
Site #13	0.2	0.041	2.1	1.7	0.3	0.001	0.001	0.002	0.002	0.020	0.001	0.000	24	15	2	3
Site #14	0.2	0.036	2.0	1.7	0.2	0.000	0.001	0.002	0.003	0.011	0.000	0.000	23	14	2	2
Site #15	0.2	0.037	2.2	1.9	0.2	0.000	0.001	0.000	0.001	0.027	0.003	0.002	13	6	0	1
Site #16	0.4	0.040	2.4	2.0	0.2	0.001	0.004	0.001	0.004	0.192	0.026	0.025	101	65	7	2
Site #17	0.2	0.041	4.0	3.4	0.5	0.003	0.002	0.002	0.004	1.213	0.006	0.005	179	82	6	2

n/a No one hour guideline

** A concentration of zero indicates that the average concentration of the pollutant was at or below the minimum detectable limit.

> Indicates the pollutant exceeded the operating range of the instrument for part of the sampling period.

Bolded numbers indicate the highest measured overall average concentration.

Table 2 shows **maximum one-hour** air quality parameter concentrations at individual monitoring locations.

Table 2 : Maximum One-Hour Average Air Quality Parameter Concentrations at each Site**																
Monitoring Location	CO (ppm)	O ₃ (ppm)	THC (ppm)	CH ₄ (ppm)	RHC (ppm)	SO ₂ (ppm)	NO (ppm)	NO ₂ (ppm)	NO _x (ppm)	NH ₃ (ppm)	TRS (ppm)	H ₂ S (ppm)	TSP (µg/m ³)	PM ₁₀ (µg/m ³)	PM _{2.5} (µg/m ³)	PAH (ng/m ³)
Site #1	0.2	0.032	1.8	1.6	0.2	0.000	0.003	0.006	0.008	0.011	0.000	0.001	8	6	1	5
Site #2	0.0	0.047	2.4	2.0	0.3	0.000	0.000	0.001	0.000	0.382	0.002	0.001	92	54	6	2
Site #3	0.5	0.050	3.0	2.6	0.3	0.003	0.005	0.003	0.006	0.600	0.002	0.001	179	104	11	2
Site #4	0.5	0.048	2.5	2.1	0.2	0.001	0.005	0.001	0.006	0.600	0.002	0.000	111	54	4	6
Site #5	0.1	0.058	1.8	1.6	0.2	0.003	0.001	0.002	0.003	0.033	0.002	0.001	49	26	3	2
Site #6	0.3	0.050	2.2	1.8	0.2	0.003	0.001	0.000	0.001	0.287	0.003	0.000	25	15	2	1
Site #7	0.0	0.058	2.2	1.9	0.2	0.004	0.000	0.002	0.002	0.186	0.003	0.001	97	56	5	1
Site #8	0.3	0.040	2.3	1.8	0.3	0.000	0.003	0.002	0.002	0.113	0.002	0.001	8	4	0	2
Site #9	0.0	0.057	2.1	1.8	0.3	0.003	0.001	0.002	0.003	0.261	0.003	0.002	151	91	8	2
Site #10	0.1	0.047	2.0	1.7	0.2	0.000	0.003	0.003	0.006	0.030	0.000	0.000	29	9	1	3
Site #11	0.1	0.047	1.9	1.6	0.2	0.003	0.005	0.002	0.007	0.023	0.002	0.001	104	58	5	2
Site #12	0.1	0.043	9.5	>7.1	1.6	0.001	0.005	0.013	0.018	0.419	no data	0.026	134	86	10	no data
Site #13	0.4	0.059	3.7	2.0	1.5	0.001	0.004	0.003	0.004	0.038	0.002	0.001	74	46	5	11
Site #14	0.3	0.051	2.2	1.9	0.2	0.000	0.003	0.003	0.005	0.015	0.000	0.001	27	17	2	2
Site #15	0.2	0.037	2.2	1.9	0.2	0.000	0.001	0.000	0.001	0.027	0.003	0.002	13	6	0	1
Site #16	1.2	0.049	3.4	3.0	0.3	0.002	0.007	0.003	0.007	0.664	0.054	0.054	442	298	32	3
Site #17	0.3	0.046	6.8	5.6	0.9	0.003	0.003	0.002	0.005	1.384	0.008	0.008	490	212	14	3
one-hour maximum	1.2	0.059	9.5	>7.1	1.6	0.004	0.007	0.013	0.018	1.384	0.054	0.054	490	298	32	11
one-hour guideline	13.0	0.082	n/a	n/a	n/a	0.170	n/a	0.210	n/a	2.0	n/a	0.010	n/a	n/a	n/a	n/a

* Data collected for only 21 minutes at Site #6

n/a No one hour guideline

** A concentration of zero indicates that the one-hour concentration of the pollutant was at or below the minimum detectable limit.

> Indicates the pollutant exceeded the operating range of the instrument for part of the sampling period.

Bolded numbers indicate the highest measured one-hour maximum concentration.

Table 3 shows one-hour average air quality parameter concentrations and weather conditions on September 1998 and February 1999 survey days at each monitoring location.

Table 3: One-hour Average Air Quality Parameter Concentrations and Weather Conditions at Each Monitoring Site (September 22 and 25, 1998 and February 22, 25 and 26, 1999) *																						
Monitoring Location	Date	Time (M.S.T.)	CO (ppm)	O ₃ (ppm)	THC (ppm)	CH ₄ (ppm)	RHC (ppm)	SO ₂ (ppm)	NO (ppm)	NO ₂ (ppm)	NO _x (ppm)	NH ₃ (ppm)	TRS (ppm)	H ₂ S (ppm)	TSP (µg/m ³)	PM ₁₀ (µg/m ³)	PM _{2.5} (µg/m ³)	PAH (ng/m ³)	Temp (Deg C)	WSP (km/h)	WDR	
Site#16	22-Sep-98	2:18 p.m. to 3:25 p.m.	1.2	0.049	2.4	2.0	0.3	0.002	0.001	0.003	0.003	0.045	no data	0.013	442	298	32	no data	21	9	NW	
Site#13		3:43 p.m. to 4:43 p.m.	0.4	0.049	2.0	1.8	0.1	0.001	0.000	0.003	0.002	0.014	no data	0.001	16	12	2	no data	20	12	N	
Site#12		5:18 p.m. to 6:16 p.m.	0.0	0.043	2.7	2.4	0.2	0.001	0.000	0.004	0.002	0.245	no data	0.001	106	73	9	no data	20	13	N	
Site#12		6:24 p.m. to 7:24 p.m.	0.1	0.033	9.5	>7.1	1.6	0.001	0.005	0.013	0.018	0.419	no data	0.026	134	86	10	no data	16	8	NE	
Site#14	25-Sep-98	7:39 a.m. to 8:39 a.m.	0.3	0.014	2.2	1.9	0.2	0.000	0.001	0.003	0.004	0.011	no data	0.000	26	16	2	no data	11	7	**	
Site#3		9:41 a.m. to 10:41 a.m.	0.5	0.016	3.0	2.6	0.3	0.000	0.001	0.003	0.004	0.289	no data	0.001	56	29	3	no data	11	12	V	
Site#13		11:30 a.m. to 12:30 p.m.	0.2	0.021	2.3	1.9	0.2	0.000	0.000	0.002	0.000	0.038	no data	0.000	2	1	0	no data	11	13	E	
Site#13	22-Feb-99	3:09 p.m. to 4:12 p.m.	0.2	0.038	2.0	1.7	0.2	0.001	0.003	0.001	0.004	0.021	0.001	0.001	23	14	2	3	6	14	W	
Site#16		4:30 p.m. to 6:04 p.m.	0.4	0.045	2.1	1.7	0.2	0.000	0.007	0.000	0.007	0.104	0.005	0.005	82	54	6	2	5	21	SW	
Site#3		6:18 p.m. to 7:20 p.m.	0.4	0.048	2.5	2.1	0.2	0.001	0.005	0.001	0.006	0.600	0.000	0.001	95	59	6	1	4	12	SW	
Site#11	25-Feb-99	9:11 a.m. to 10:10 a.m.	0.1	0.047	1.9	1.6	0.2	0.001	0.005	0.002	0.007	0.023	0.001	0.000	104	58	5	2	12	19	SW	
Site#14		10:25 a.m. to 11:28 a.m.	0.2	0.051	1.9	1.6	0.1	0.000	0.001	0.000	0.001	0.008	0.000	0.000	27	17	2	2	13	27	S	
Site#3		12:10 p.m. to 1:12 p.m.	0.2	0.050	2.1	1.7	0.2	0.003	0.001	0.000	0.001	0.216	0.002	0.000	68	39	4	1	13	27	SW	
Site#6		1:21 p.m. to 2:21 p.m.	0.3	0.050	2.2	1.8	0.2	0.003	0.001	0.000	0.001	0.287	0.003	0.000	25	15	2	1	12	22	W	
Site#13		3:05 p.m. to 4:04 p.m.	0.2	0.044	1.9	1.6	0.2	0.001	0.001	0.002	0.003	0.016	0.000	0.000	30	21	3	3	12	20	SW	
Site#13		4:05 p.m. to 5:24 p.m.	0.3	0.040	2.0	1.6	0.2	0.001	0.002	0.002	0.004	0.026	0.000	0.000	43	30	4	3	10	17	SW	
Site#16		5:34 p.m. to 6:37 p.m.	0.3	0.037	2.1	1.7	0.2	0.001	0.005	0.000	0.005	0.122	0.034	0.034	70	47	6	2	9	13	W	
Site#13	26-Feb-99	9:40 a.m. to 10:50 a.m.	0.2	0.038	3.7	2.0	1.5	0.001	0.004	0.001	0.004	0.021	0.000	0.000	9	6	1	2	7	15	SW	
Site#16		11:01 a.m. to 12:02 p.m.	0.4	0.045	2.1	1.7	0.2	0.000	0.007	0.000	0.007	0.104	0.041	0.042	5	3	0	1	9	19	W	
Site#4		12:33 p.m. to 1:33 p.m.	0.5	0.048	2.5	2.1	0.2	0.001	0.005	0.001	0.006	0.600	0.002	0.000	111	54	4	6	12	12	W	
one-hour guideline			13.0	0.082	n/a	n/a	n/a	0.170	n/a	0.210	n/a	2.0	n/a	0.010	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

* a concentration of zero indicates the pollutant was at or below the minimum detectable limit.
no data - indicates that analyzer was not operational for indicated time period
n/a - indicates no one hour guideline

V - indicates wind was from variable directions
> indicates the pollutant exceeded the operating range of the instrument for part of the sampling period

List of Air Quality and Weather Parameters

CO - carbon monoxide	RHC - reactive hydrocarbons	NO _x - total oxides of nitrogen	PAH - polycyclic aromatic hydrocarbons	Temp - ambient temperature
O ₃ - ozone	SO ₂ - sulphur dioxide	NH ₃ - ammonia	TSP - total suspended particulates	WSP - wind speed
THC - total hydrocarbons	NO - nitric oxide	THS - total reduced sulphur	PM ₁₀ - inhalable particulates	WDR - wind direction
CH ₄ - methane	NO ₂ - nitrogen dioxide	H ₂ S - hydrogen sulphide	PM _{2.5} - respirable particulates	

Table 4 shows one-hour average air quality parameter concentrations and weather conditions on May 1999 and July 1999 survey days at each monitoring location.

Monitoring Location	Date	Time (M.S.T.)	CO (ppm)	O ₃ (ppm)	THC (ppm)	CH ₄ (ppm)	RHC (ppm)	SO ₂ (ppm)	NO (ppm)	NO ₂ (ppm)	NO _x (ppm)	NH ₃ (ppm)	TRS (ppm)	H ₂ S (ppm)	TSP (µg/m ³)	PM ₁₀ (µg/m ³)	PM _{2.5} (µg/m ³)	PAH (ng/m ³)	Temp (Deg C)	WSP (km/h)	WDR
Site#13	10-May-99	1:47 p.m. to 3:04 p.m.	0.2	0.053	1.9	1.7	0.2	0.001	0.000	0.000	0.001	0.001	0.001	0.000	2	2	1	1	5	23	V
Site#10		3:58 p.m. to 4:59 p.m.	0.1	0.047	2.0	1.7	0.2	0.000	0.003	0.003	0.006	0.030	0.000	0.000	29	9	1	3	6	19	N
Site#3		5:28 p.m. to 6:32 p.m.	0.1	0.047	2.6	2.3	0.3	0.001	0.002	0.000	0.002	0.220	0.001	0.001	5	3	1	2	5	12	N
Site#11	13-May-99	8:04 a.m. to 9:06 a.m.	***	***	***	***	***	0.003	***	***	***	***	0.002	0.001	***	***	***	***	9	3	SW
Site#14		9:22 a.m. to 10:22 a.m.	0.2	0.044	1.8	1.6	0.2	0.000	0.003	0.002	0.005	0.015	0.000	0.001	17	11	2	2	10	5	SE-NE
Site#5		12:34 p.m. to 1:41 p.m.	0.1	0.058	1.8	1.6	0.2	0.003	0.001	0.002	0.003	0.033	0.002	0.001	49	26	3	2	13	17	NE
Site#9		2:00 p.m. to 3:11 p.m.	0.0	0.057	2.1	1.8	0.3	0.003	0.001	0.002	0.003	0.261	0.003	0.002	151	91	8	2	15	11	N-NE
Site#13		3:35 p.m. to 4:39 p.m.	0.0	0.059	1.8	1.5	0.2	0.001	0.000	0.002	0.001	0.021	0.000	0.001	40	22	3	11	15	14	V
Site#7		4:49 p.m. to 5:54 p.m.	0.0	0.058	2.2	1.9	0.2	0.004	0.000	0.002	0.002	0.186	0.003	0.001	97	56	5	1	13	11	NE
Site#1	14-May-99	8:02 a.m. to 9:02 a.m.	0.2	0.032	1.8	1.6	0.2	0.000	0.003	0.005	0.008	0.011	0.000	0.001	8	6	1	5	8	12	V
Site#1		9:03 a.m. to 9:50 a.m.	0.2	0.031	1.8	1.6	0.2	0.000	0.002	0.006	0.008	0.007	0.000	0.001	6	5	1	5	8	14	SE-SW
Site#16		10:20 a.m. to 11:23 a.m.	0.1	0.033	2.0	1.7	0.2	0.001	0.005	0.000	0.005	0.044	0.054	0.054	1	1	0	2	7	29	W
Site#16 **		11:49 a.m. to 12:21 p.m.	0.3	0.036	1.8	1.6	0.2	0.001	0.002	0.003	0.005	0.019	0.001	0.001	2	1	0	2	6	39	NW
Site#16		12:23 p.m. to 12:54 p.m.	0.5	0.034	1.9	1.6	0.2	0.000	0.006	0.000	0.006	0.021	0.046	0.047	1	1	0	2	6	36	NW
Site#13		1:20 p.m. to 2:21 p.m.	0.2	0.037	1.9	1.6	0.2	0.001	0.002	0.002	0.004	0.035	0.002	0.001	1	1	0	2	6	32	W
Site#13	18-Jul-99	12:12 p.m. to 1:15 p.m.	0.1	0.036	1.9	1.6	0.2	0.000	0.001	0.000	0.001	0.000	0.001	0.000	2	2	0	1	17	16	W
Site#15		1:40 p.m. to 2:41 p.m.	0.2	0.037	2.2	1.9	0.2	0.000	0.001	0.000	0.001	0.027	0.003	0.002	13	6	0	1	18	12	W
Site#16		2:53 p.m. to 4:04 p.m.	0.2	0.037	2.5	2.2	0.3	0.000	0.002	0.000	0.002	0.192	0.016	0.016	4	2	0	3	18	11	W
Site#8		5:10 p.m. to 6:12 p.m.	0.3	0.040	2.3	1.8	0.3	0.000	0.003	0.002	0.002	0.113	0.002	0.001	8	4	0	2	22	5	S
Site#13	21-Jul-99	8:00 a.m. to 9:04 a.m.	0.0	0.028	2.1	1.7	0.2	0.000	0.001	0.002	0.004	0.018	0.001	0.000	74	46	5	3	22	4	SW
Site#17		9:43 a.m. to 10:43 a.m.	0.1	0.041	3.2	2.9	0.3	0.002	0.003	0.002	0.005	1.170	0.005	0.004	109	56	5	3	25	8	W
Site#17		10:44 a.m. to 11:44 a.m.	0.0	0.043	3.2	2.9	0.3	0.003	0.002	0.001	0.003	1.364	0.005	0.005	71	36	4	1	26	10	W
Site#17		11:45 a.m. to 12:42 p.m.	0.3	0.046	2.9	2.4	0.4	0.003	0.002	0.002	0.004	1.131	0.005	0.004	47	23	2	1	27	8	W
Site#16		1:06 p.m. to 2:05 p.m.	0.2	0.049	2.2	1.8	0.3	0.001	0.001	0.001	0.002	0.258	0.006	0.007	89	50	5	2	30	12	SW
Site#13		2:32 p.m. to 3:33 p.m.	0.1	0.050	1.9	1.6	0.2	0.000	0.000	0.001	0.000	0.033	0.000	0.000	40	24	3	4	31	6	S
Site#2		3:53 p.m. to 5:05 p.m.	0.0	0.047	2.4	2.0	0.3	0.000	0.000	0.001	0.000	0.382	0.002	0.001	92	54	6	2	30	16	SW
Site#3		5:36 p.m. to 6:36 p.m.	0.1	0.044	2.5	2.1	0.3	0.000	0.000	0.001	0.000	0.264	0.002	0.001	179	104	11	2	27	10	SW
Site#16		6:51 p.m. to 7:51 p.m.	0.1	0.027	3.4	3.0	0.3	0.001	0.003	0.002	0.004	0.664	0.024	0.027	119	65	6	2	24	9	W
Site#17		8:08 p.m. to 9:06 p.m.	0.3	0.036	6.8	5.6	0.9	0.003	0.002	0.002	0.004	1.186	0.008	0.008	490	212	14	2	21	9	NE
one-hour guidelines			13.0	0.062	n/a	n/a	n/a	0.170	n/a	0.210	n/a	2.0	n/a	0.010	n/a	n/a	n/a	n/a	n/a	n/a	n/a

* - a concentration of zero indicates the pollutant was at or below the minimum detectable limit.

** - indicates the monitoring was done upwind of the source to ensure there was no other source around.

n/a - indicates no one hour guideline.

V - indicates wind was from variable directions.

*** - indicates that less than 75% of a one hour period available due to interference from MAML exhaust.

Data in *italics* - indicates that monitoring was conducted for less than 75% of a one hour period.

List of Air Quality and Weather Parameters

CO - carbon monoxide	RHC - reactive hydrocarbons	PAH - polycyclic aromatic hydrocarbons	Temp - ambient temperature
O ₃ - ozone	SO ₂ - sulphur dioxide	TSP - total suspended particulates	WSP - wind speed
THC - total hydrocarbons	NO - nitric oxide	PM ₁₀ - inhalable particulates	WDR - wind direction
CH ₄ - methane	NO ₂ - nitrogen dioxide	PM _{2.5} - respirable particulates	

Table 5 shows the **weather conditions, distance** (in metres) the MAML was monitoring from the nearest livestock feeding operation and the **MAML operator's comments**.

Table 5: Monitoring Distance from the Source*, Weather Conditions, and MAML Operator's Comments**

Monitoring Location	Date	Time (M.S.T.)	Temp	WSP	WDR	Distance from Source	Cloud	Operator's Comments
Site#16	22-Sep-98	2:18 p.m. to 3:25 p.m.	21	9	NW	15-20m	20%	Stopped downwind of hog feedlot.
Site#13		3:43 p.m. to 4:43 p.m.	20	12	N	n/a	30%	No comments provided by MAML operator
Site#12		5:18 p.m. to 6:16 p.m.	20	13	N	800m	30%	Stopped approx. 1/4 mile south of hog feedlot
Site#12		6:24 p.m. to 7:24 p.m.	16	8	NE	25m	n/a	Stopped on roadside beside hog barns, odours
Site#14	25-Sep-98	7:39 a.m. to 8:39 a.m.	11	7	no data	n/a	100%	No rain.
Site# 3		10:42 a.m. to 11:29 a.m.	11	10	NW	50-60m	100%	Rain.
Site#13		11:30 a.m. to 12:30 p.m.	11	13	E	n/a	n/a	No comments provided by MAML operator
Site#13	22-Feb-99	3:09 p.m. to 4:12 p.m.	6	14	W	n/a	60%	Dry conditions, no snow.
Site#16		4:30 p.m. to 6:04 p.m.	5	21	SSW	15-20m	85%	Stopped at hog feedlot. Odours, most odors are coming off pond H2S and TRS peak, 14 ppb. Lots of road dust
Site# 3		6:18 p.m. to 7:20 p.m.	4	12	SW	60m	85%	Some odours
Site#11	25-Feb-99	9:11 a.m. to 10:10 a.m.	12	19	SW	20-30m	20%	Stopped at cattle feedlot (strong odour from cattle feed being loaded onto truck, slight cattle odour)
Site#14		10:25 a.m. to 11:28 a.m.	13	27	S	n/a	20%	No comments provided by MAML operator
Site# 3		12:10 p.m. to 1:12 p.m.	13	27	SW	60m	30%	Slight odours
Site# 6		1:21 p.m. to 2:21 p.m.	12	22	W	50m	70%	No comments provided by MAML operator
Site#13		3:05 p.m. to 4:04 p.m.	12	20	SW	n/a	n/a	No comments provided by MAML operator
Site#13		4:05 p.m. to 5:24 p.m.	10	17	SW	n/a	n/a	No comments provided by MAML operator
Site#16		5:34 p.m. to 6:37 p.m.	9	13	W	15-20m	80%	Stopped by hog operation. H2S peak 48 ppb
Site#13		9:40 a.m. to 10:50 a.m.	7	15	SW	n/a	25%	Very slight odour.
Site#16	26-Feb-99	11:01 a.m. to 12:02 p.m.	9	19	W	15-20m	20%	No comments provided by MAML operator
Site# 4		12:33 p.m. to 1:33 p.m.	12	12	W	30m	20%	Particulate from road dust and/or loading cattle feed onto truck
Site#13		1:47 p.m. to 3:04 p.m.	5	23	V	n/a	n/a	No comments provided by MAML operator
Site#10	10-May-99	3:58 p.m. to 4:59 p.m.	6	19	N	60m	100%	No rain or snow. Particulate coming from truck carrying feed. Ground is wet, so there is no road dust.
Site# 3		5:26 p.m. to 6:32 p.m.	5	12	N	60m	100%	No rain. Roads are damp. PAH reading from diesel exhaust
Site#11	13-May-99	8:04 a.m. to 9:06 a.m.	9	3	SW	20-30m	95%	Stopped adjacent to feedlot (holds a max. of 1000 head of cattle). Slight odours.
Site#14		9:22 a.m. to 10:22 a.m.	10	5	SE-NE	n/a	40%	No comments provided by MAML operator
Site# 5		12:34 p.m. to 1:41 p.m.	13	17	NE	50m	80%	Stopped downwind of cattle feedlot. Feedlot odours. Picking up feedlot odours all down hwy 845.
Site# 9		2:00 p.m. to 3:11 a.m.	15	11	N-NE	90m	75%	Stopped adjacent to feedlot which has 12,000 head of cattle. NH3 peak 680 ppb
Site#13		3:35 p.m. to 4:39 p.m.	15	14	V	n/a	70%	No comments provided by MAML operator
Site# 7		4:49 p.m. to 5:54 p.m.	13	11	NE	50-60m	70%	No comments provided by MAML operator
Site# 1		8:02 a.m. to 9:02 a.m.	8	12	V	n/a	100%	Rained overnight.
Site# 1		9:03 a.m. to 9:50 a.m.	8	14	SE-SW	n/a	100%	Rain.
Site#16	14-May-99	10:20 a.m. to 11:23 a.m.	7	29	W	40m	100%	Downwind of hog feedlot lagoon. Very strong odour. Light rain
Site#16		11:49 a.m. to 12:21 p.m.	6	39	NW	30m	100%	Upwind of hog feedlot lagoon to help isolate the odour source
Site#16		12:23 p.m. to 12:54 p.m.	6	36	NW	40m	100%	Downwind of hog feedlot lagoon. Strong odors and picking up H2S again. Light rain. H2S dropped off when MAML left area
Site#13		1:20 p.m. to 2:21 p.m.	6	32	W	n/a	100%	No rain. Cattle feedlot odour
Site#13	18-Jul-99	12:12 p.m. to 1:15 p.m.	17	16	W	n/a	80%	Stopped raining
Site#15		1:40 p.m. to 2:41 p.m.	18	12	W	40m	90%	Directly east of a hog feedlot. Odours. No rain
Site#16		2:53 p.m. to 4:04 p.m.	18	11	W	15-20m	80%	No rain. Stop on E side of feedlot (about 2,600 head of hogs)
Site# 8		5:10 p.m. to 6:12 p.m.	22	5	S	60m	50%	No rain. Odours detected from cattle feedlot NW of MAML
Site#13	21-Jul-99	8:00 a.m. to 9:04 a.m.	22	4	SW	n/a	n/a	Sunny, odours come and go.
Site#17		9:43 a.m. to 10:43 a.m.	25	8	W	30-35m	n/a	Stopped S of feedlot that holds up to 26,000 head of cattle.
Site#17		10:44 a.m. to 11:44 a.m.	26	10	W	30-35m	n/a	Sunny but very hazy over a long distance. Particulates may be high.
Site#17		11:45 a.m. to 12:42 p.m.	27	8	W	30-35m	n/a	No comments provided by MAML operator
Site#16		1:06 p.m. to 2:05 p.m.	30	12	SW	15-20m	n/a	Stopped S of hog lagoon (odours), road dust. Sunny.
Site#13		2:32 p.m. to 3:33 p.m.	31	6	S	n/a	n/a	Sunny and still hazy.
Site# 2		3:53 p.m. to 5:05 p.m.	30	16	SW	100m	n/a	Sunny.
Site# 3		5:36 p.m. to 6:36 p.m.	27	10	SW	300m	n/a	Road dust, sunny.
Site#16	21-Jul-99	6:51 p.m. to 7:51 p.m.	24	9	W	15-20m	n/a	Sunny.
Site#17		8:08 p.m. to 9:06 p.m.	21	9	NE	30-35m	n/a	No traffic. TSP and PM ₁₀ are elevated. Whole area seems to have a hazy look. Particulates dropped upon leaving downwind of feedlot.

* the source being the feedlot fence line or lagoon fence line

V - indicates wind was from variable directions

** Weather conditions are based on observations at the monitoring site. Units are temperature [°C], wind speed [km/h] and cloud cover [% of sky coverage]

Appendix 1

EFFECTS OF HYDROGEN SULPHIDE AT VARIOUS AIR CONCENTRATIONS ¹

Concentration (ppm)	Effects
0.01	1 hour average. Alberta Ambient Air Quality Guideline
0.01 – 0.3	Odour threshold (highly variable)
0.25 – 0.3	Mildly offensive odour, may be associated with headaches, sleep disturbances
1 – 5	Moderate offensive odour, may be associated with nausea, tearing of eyes, headaches or loss of sleep with prolonged exposure; healthy young male subjects experience no decline in maximal physical work capacity
10	8 hour occupational exposure limit in Alberta
15	15 minute occupational exposure limit in Alberta
20	Ceiling occupational exposure limit and community evacuation level in Alberta, odour very strong
20 – 50	Keratoconjunctivitis (eye irritation) and lung irritation. Possible eye damage after several days of exposure; may cause digestive upset and loss of appetite
50 – 100	Eye and lung irritation; olfactory paralysis, odour disappears
150 – 250	Sense of smell paralyzed; severe eye and lung irritation
250 – 500	Pulmonary oedema may occur, especially if exposure is prolonged
500 – 1000	Serious damage to eyes within 30 minutes; severe lung irritation; unconsciousness and death within 4 – 8 hours; amnesia for period of exposure; "knockdown"
1000 – 2000	Breathing may stop within one or two breaths; immediate collapse, apnea, hypoxia, hypoxic encephalopathy or death certain

¹ Adapted from the following references:

Guidotti, Tee L. 1994. "Occupational Exposure to Hydrogen Sulphide in the Sour Gas Industry: Some Unresolved Issues". *International Archives of Occupational and Environmental Health* 66:153-160.

Guidotti, Tee L. 1996. "Hydrogen Sulphide". *Occupational Medicine* 46,5:367-371.

Milby, Thomas H. and Randall C. Baselt. 1999. "Health Hazards of Hydrogen Sulphide: Current Status and Future Directions". *Environmental Epidemiology and Toxicology* 1, 3-4:262-269.

Appendix 2

Effects of Ammonia at Various Air Concentrations¹

Concentration (ppm)	Exposure (minutes)	Effects
2		1-hour average. Alberta Ambient Air Quality Guideline
0.0376-55.9		Odour threshold low and high
30	10	No increase in symptoms indicative of irritation
40	chronic	Headache, nausea, and reduced appetite
50	10	Moderate irritation
	30	Eye, nose, or throat irritation, or cough urge
72	5	Eye irritation, nasal irritation, and throat irritation
134	5	Irritation and tearing of the eyes, complaints of nasal irritation, throat irritation, and chest irritation
140	30	Irritation of the eyes, nose or throat or the urge to cough reported
395		Throat irritation observed
57-500	up to 2	Nasal mucosa retained 83% - 92% of the inhaled ammonia
500	10-27	Nasal mucosa retained 20% - 30% of the inhaled ammonia. Nasal and pharyngeal irritation, but no tracheal irritation
	30	Upper respiratory irritation was reported for all test subjects
1694		Cough resulted
2400		Life-threatening
above 4942		Death may occur

¹ Adapted from the following references:

Alberta Environment, Environmental Sciences Division. 2000. Alberta Ambient Air Quality Guidelines.

ATSDR, 1990. Toxicological Profile for Ammonia. U.S. Public Health Service, Agency for Toxic Substances and Disease Registry. TP-90-03. 125p.

OEHHA, 1998. Technical Support for the Determination of Acute Reference Exposure Levels for Airborne Toxicants - Ammonia. Office of Environmental Health Hazard Assessment, California Environmental Protection Agency, California, U.S.A.

Ruth, Jon H. 1986. Odor Thresholds and Irritation Levels of Several Chemical Substances: A Review. American Industrial Hygiene Association 47: 142-151.

US EPA, 1989. Summary Review of Health Effects Associated with Ammonia. Health Issue Assessment. Office of Research and Development. U.S. Environmental Protection Agency. Research Triangle Park, NC. EPA/600/8/8-89/052F.

WHO, 1986. Environmental Health Criteria No 54: Ammonia. (IPCS Programme on Chemical Safety), Geneva, 210p.

Appendix 3

Reasons for Creation of Hydrogen Sulphide and Ammonia from Hog and Cattle Feeding Operations

There are three kinds of manure:

- liquid manure, which is the main source of ammonia, with a dry matter content of no more than 3%;
- mixed manure is a mixture of feces, urine and parts of the bedding and can be pumped, with a dry matter content of 2 to 20%;
- solid manure, with a dry matter content of at least 35 to 40 percent.

The primary difference between hog and cattle manure odours is related to the way the manure is stored. Hog manure tends to be stored as a liquid in a lagoon. It may remain in storage for several months before removal. Under these conditions (absence of oxygen) anaerobic breakdown by micro-organisms takes place. Swine feces are rich in nutrients and their breakdown by anaerobic bacteria produces highly odorous compounds, many of which are sulphides (including hydrogen sulphide), sulphur containing compounds, organic acids, phenolics and more. In addition, hog barns are heated from 24 to 28°C and these high temperatures accelerate the breakdown of manure. Forced ventilation systems push air from the hog barn outside.

Cattle feedlots tend to store manure outdoors in the feeding pens. This allows for more aerobic (presence of oxygen) storage and nutrient breakdown by aerobic micro-organisms. Compounds are oxidized but also produce ammonia and other gasses.

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